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ABSTRACT

In order to implement a program to integrate mathematics and science instruction at the middle school level a proposal was developed which cited the need for students to recognize the interdependence of science and mathematics by applying quantitative methods to the analysis and communication of scientific concepts, and, through such application, to be aware that mathematics carries the main burden of scientific reasoning and is the core of the major theories of physical science. Some findings of the evaluation of this program include: (1) the vast majority of participating teachers felt that the use of the objectives of the program had enhanced the quality of their classroom teaching; (2) teachers felt that their awareness of the relationship between science and math had increased; and (3) communication and sharing among teachers had improved as a result of participation in the program. Proposal goals are listed for teachers and students. (MVL)

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PROGRAM TO INTEGRATE MATH AND SCIENCE

Evaluation Report

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August, 1987

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Program to Integrate Math and Science

Evaluation Report

August, 1987

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ADMINISTRATIVE SUMMARY

In order to implement a program to integrate Mathematics and Science instruction at the middle school level, Hilde Howden, Albuquerque Public Schools Mathematics Coordinator, and Mary Ann Esquibel, Albuquerque Public Schools Science Coordinator, submitted a proposal to the TRW Foundation for funding in March of 1986. With this funding the district developed a model for inservice training of twenty-four middle school Science and Mathematics teachers in inquiry teaching and in interrelating Science and Mathematics concepts. In addition, activities prepared in the training program were implemented at six middle school sites on a one-year pilot basis, and a Program Implementation Guide was created which could be used by other districts who are interested in replicating the program. Below are summarized the major findings of the evaluation of this program. The reported figures are based on a survey of all twenty-four teachers who participated in the program.

- The vast majority of participating teachers felt that the use of the objectives of the program had enhanced the quality of their classroom teaching.

- Thirteen teachers reported an increase in students' interest in Science, compared to ten who felt that students' interest in Science had not changed.

- Twelve teachers reported an increase in students' interest in Math, and twelve teachers felt that there had been no change in students' level of interest in Math.

- Eleven teachers reported that they observed an increase in students' understanding of Science, while twelve teachers observed no increase. Thirteen teachers reported an increase in students' understanding of Math, while eleven reported no increase.

- Eight teachers reported observing an increase in Science performance, while fourteen observed no increase. Nine teachers reported an increase in performance in Math, while fifteen reported no increase.

- Eighteen teachers reported that they saw an increase in students' interest in the relationship between Science and Math, compared to five who did not.

- Twenty teachers reported that they observed an increase in students' understanding of the relationship between Science and Math, compared to four who did not.

- The majority of teachers participating in the program changed both the way they planned lessons and the way they presented material in class.

- Teachers felt that their awareness of the relationship between Science and Math had increased, and communication and sharing among teachers had improved as a result of participation in the program.

- Nearly all participating teachers reported that they would continue to plan with other teachers to integrate the instruction of Science and Math, and felt that the program should be repeated again with a different group of teachers.

INTRODUCTION

In March of 1986, Hilde Howden, Albuquerque Public Schools Mathematics Coordinator, and Mary Ann Esquibel, Albuquerque Public Schools Science Coordinator, submitted a proposal to the TRW Foundation for funding to implement a program to integrate Mathematics and Science instruction (PIMS) at the middle school level. The request was for funds to develop a model for inservice training of middle school Science and Mathematics teachers in inquiry teaching and in interrelating Science and Mathematics concepts; to implement activities prepared in the training program at six middle school sites on a one-year pilot basis; and to develop a Program Implementation Guide that could be used for expanded implementation of the program in the Albuquerque Public Schools for national replication.

The proposal cited the need for students to recognize the interdependence of Science and Mathematics by applying quantitative methods to the analysis and communication of scientific concepts, and, through such application, to be aware that Mathematics carries the main burden of scientific reasoning and is the core of the major theories of Physical Science.

Each of the twenty-three middle schools in the Albuquerque Public Schools had the opportunity to apply for participation in the pilot project. Six were selected on the basis of their commitment, as evidenced in their written proposals, to support and implement the program. These selections were made by the District's Assistant Superintendent for Instruction, the District Coordinator of Mathematics, and the District Coordinator of Science.

In the proposal to the TRW Foundation, specific goals for teachers and students were identified. In the pilot program, teachers were asked to:

- identify interactions of Science and Mathematics concepts taught in the middle school curricula;
- utilize an inquiry-oriented approach to teaching Mathematics and Science;
- develop inquiry-learning activities that focus on the interactions of Science and Mathematics concepts;
- use the developed activities in teaching their classes during the pilot year of the program;
- keep a log of the activities used together with the Mathematics and Science concepts for which they were used;
- meet on a monthly basis to share activities and strategies for using them;
- develop a Program Implementation Guide for continued implementation of the program;
- provide an inservice workshop for district secondary Mathematics and Science teachers.

The proposal anticipated that students would:

- use the inquiry approach in learning Mathematics and Science;
- recognize interactions of Science and Mathematics concepts in their curriculum content;
- become aware of the importance of studying Mathematics and Science;
- be able to answer the question, "Why do we need to know this?" as it applies to what they are studying in Mathematics and Science.

The training program was initiated with a two-week summer institute, and continued throughout the school year through monthly meetings of all participating teachers

and a teacher network which was facilitated by the Program Coordinator. These monthly meetings allowed time to share success, areas of concern, and newly developed activities; to review video-taped lessons; and to plan the Program Implementation Guide, which will serve as a national model. During the intervals between monthly meetings, the Program Coordinator monitored progress at each school site, kept a record of teacher and student reactions to the program, facilitated networking among participating schools and individual teachers, and assisted teachers in developing components of the Program Implementation Guide.

Implementation at selected school sites varied, depending upon the scheduling arrangements at the individual schools. In all schools, participating teachers jointly planned lessons to insure that the interactions of Science and Mathematics concepts reinforced each other. In those schools where scheduling allowed, the Mathematics and Science classes met in back-to-back, two-period blocks with Science and Mathematics teachers functioning as a team.

PROFILE OF TEACHERS PARTICIPATING IN THE PROGRAM

A total of twenty-four teachers participated in the pilot project, four from each of six participating schools. Of the twenty-four teachers, thirteen taught Math, eight taught Science, and three taught both Science and Math.

Figure I represents the mean number of years of teaching experience of the participants. Included are figures for years of experience at their present school sites, years of experience in their present content area (Math or Science), and total years of teaching experience.

Figure I

Mean Years Experience of Participating Teachers

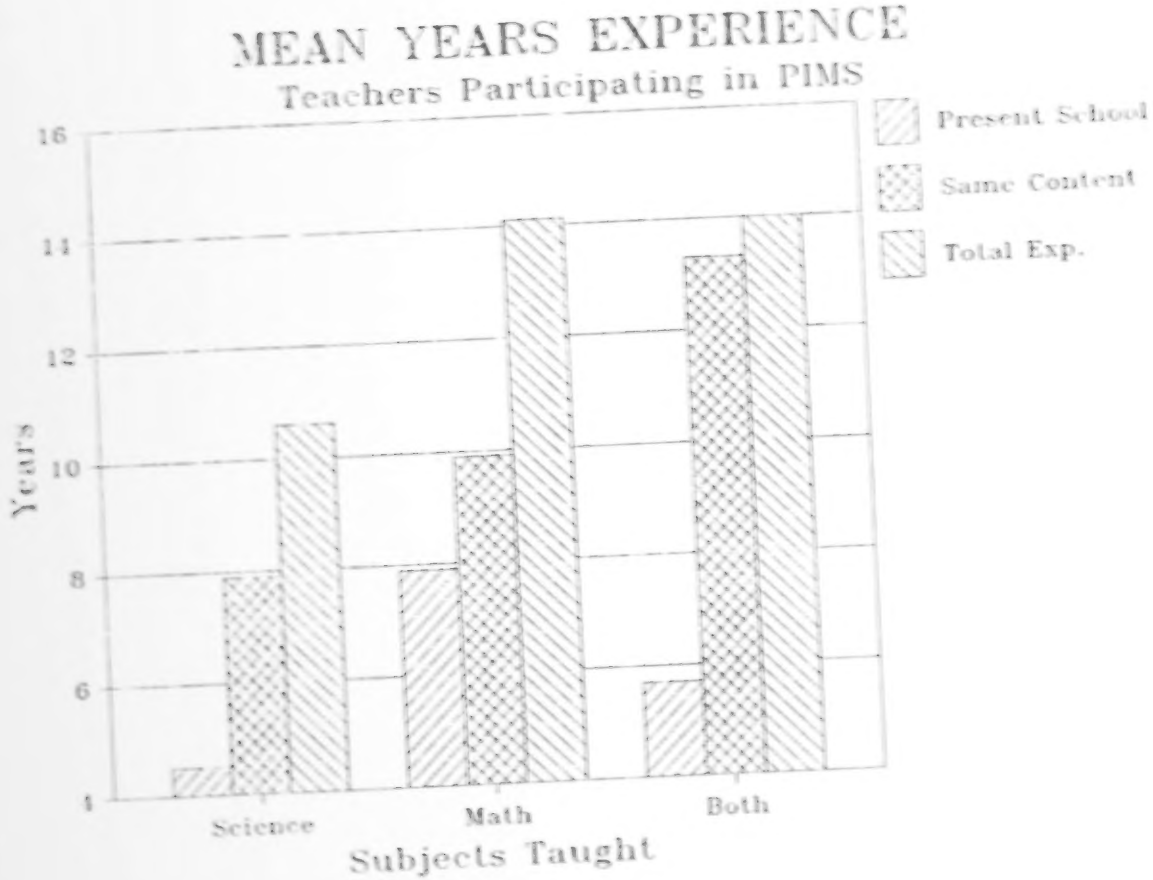
Years at Present School	
Science Teachers	4.5
Math Teachers	7.9
Teachers of both Science and Math	5.7
Average for All Participating Teachers	6.5
Years in Present Content Area	
Science Teachers	7.9
Math Teachers	9.9
Teachers of both Science and Math	13.3[a]
Average for All Participating Teachers	9.7
Years Total Teaching Experience	
Science Teachers	10.6
Math Teachers	14.1
Teachers of both Science and Math	14.0
Average for All Participating Teachers	12.9

[a]This figure represents experience in teaching Science and/or Math.

As can be seen from these figures, those Math teachers participating in the project had more experience than participating Science teachers, including total teaching experience, experience teaching their respective subjects, and experience at their present locations. These figures also indicate that many of the participating teachers had experience at other schools and with other subjects.

Figure II is a graphic representation of the data included in Figure I.

Figure II



Of interest here is the observation that the Science teachers involved in the Project to Integrate Math and Science were the least experienced in all three areas (length of time at present location, experience with present content area, and total years teaching experience). Math teachers, on the other hand, had the most overall teaching experience, and had the longest tenure at their present locations.

EFFECTS OF PIMS ON THE PARTICIPANTS' CLASSROOM TEACHING

All participants in PIMS were asked to rate the effect of three major objectives of the program on their individual classroom teaching. The goals rated for effect were: 1) identification of interactions of Science and Math; 2) utilization of examples of interactions of Science and Math; and 3) use of activities developed by self and other teachers.

Figure III represents the perceptions of participating teachers of the effect which these three objectives had on their classroom teaching.

Figure III

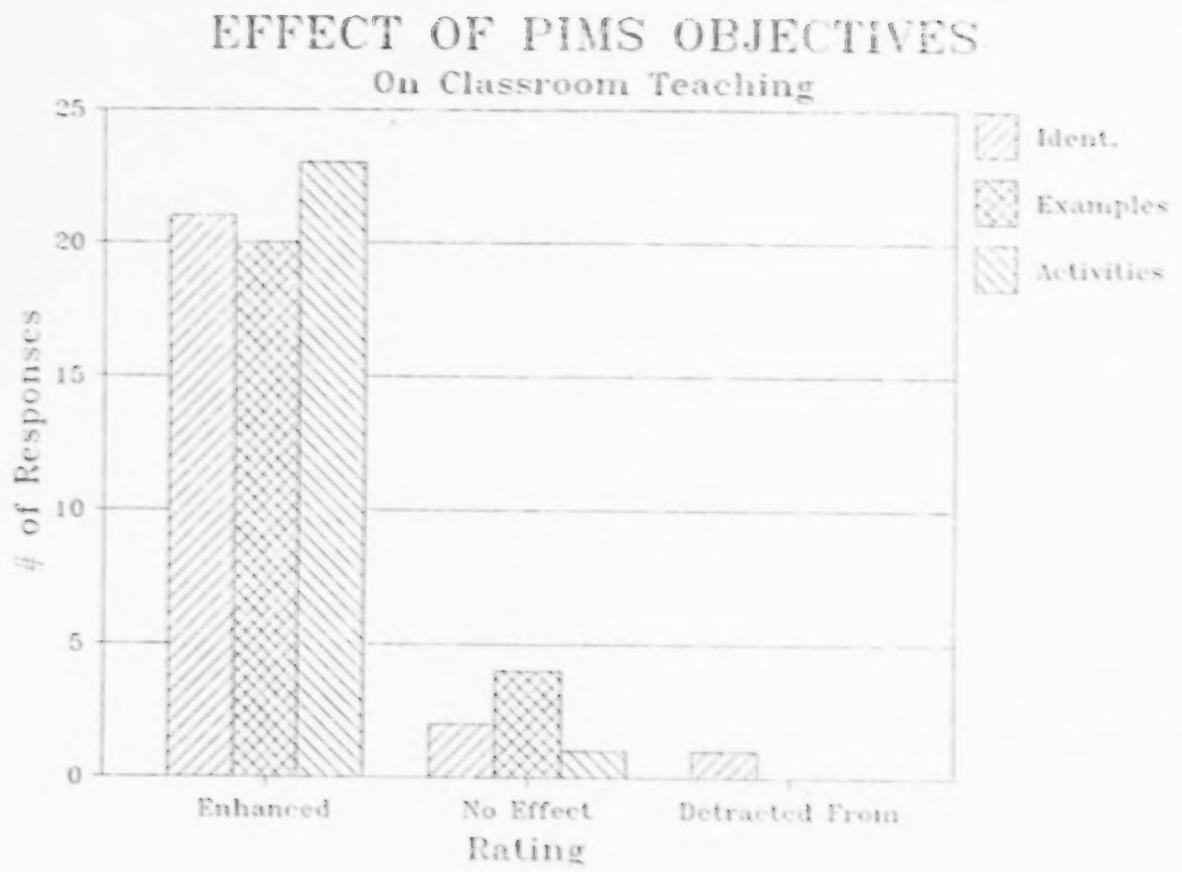
Effects of PIMS on Participants' Classroom Teaching

Objective	Rating			
Identification of interactions of Science and Math.	en-hanced	no effect	detracted from	did not use
Science Teachers (N=8)	75.0%	12.5%	12.5%	0.0%
Math Teachers (N=13)	92.3%	7.7%	0.0%	0.0%
Teachers of Both Science and Math (N=3)	100.0%	0.0%	0.0%	0.0%
Total (N=24)	87.5%	8.3%	4.2%	0.0%
Utilization of examples of interactions of Science and Math.				
Science Teachers (N=8)	87.5%	12.5%	0.0%	0.0%
Math Teachers (N=13)	84.6%	15.4%	0.0%	0.0%
Teachers of Both Science and Math (N=3)	66.7%	33.3%	0.0%	0.0%
Total (N=24)	83.3%	16.7%	0.0%	0.0%
Use of activities developed by myself and other teachers.				
Science Teachers (N=8)	100.0%	0.0%	0.0%	0.0%
Math Teachers (N=13)	92.3%	7.7%	0.0%	0.0%
Teachers of Both Science and Math (N=3)	100.0%	0.0%	0.0%	0.0%
Total (N=24)	95.8%	4.1%	0.0%	0.0%

These results indicate that all of the objectives were being utilized by teachers, and that the overwhelming majority of participants felt that the objectives enhanced their classroom teaching. A small percentage of teachers felt that use of the objectives had no effect on their classroom teaching, while only one teacher felt that attempts to identify the interaction of Math and Science detracted from the quality of instruction.

Figure IV is a graphic representation of the data presented in Figure III.

Figure IV



Although all the activities were viewed by the majority of participating teachers as having an enhancing effect on their classroom teaching, the most helpful appear to be the use of activities developed by teachers.

EFFECTS OF PIMS ON STUDENTS

Participating teachers were asked to note their observations of the effects of PIMS on students with regard to their interest in, understanding of, and performance in Science and Math.

Figure V summarizes the responses of participating teachers to survey questions about student interest in Science and Math.

Figure V

Effects of PIMS on Students' Interest

Area of Emphasis	Teacher Ratings		
Interest in Science	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	50.0%	50.0%	0.0%
Students of Math Teachers (N=12)	58.3%	41.7%	0.0%
Students of Teachers of Both Science and Math (N=3)	66.7%	33.3%	0.0%
Totals (N=23)	56.5%	43.5%	0.0%
Interest in Math	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	62.5%	37.5%	0.0%
Students of Math Teachers (N=13)	46.2%	53.8%	0.0%
Students of Teachers of Both Science and Math (N=3)	50.0%	50.0%	0.0%
Totals (N=24)			

These figures reveal that teachers were of the opinion that PIMS was more effective in increasing student interest in Science than in Math. However, even in the case of Math, half of the teachers observed that the integration of the instruction of Math and Science increased student interest in the subject.

Figure VI summarizes teachers' observations of the effect of PIMS on students' understanding of Science and Math.

Figure VI

Effect of PIMS on Students' Understanding

Area of Emphasis	Teacher Ratings		
Understanding of Science	Increased	Remained Same	Decreased
Students of Science Teachers (N=8)	62.5%	37.5%	0.0%
Students of Math Teachers (N=12)	41.7%	58.3%	0.0%
Students of Teachers of Both Science and Math (N=3)	33.3%	66.7%	0.0%
Totals (N=23)	47.8%	52.2%	0.0%
Understanding of Math	Increased	Remained Same	Decreased
Students of Science Teachers (N=8)	50.0%	50.0%	0.0%
Students of Math Teachers (N=13)	53.8%	46.2%	0.0%
Students of Teachers of Both Science and Math (N=3)	66.7%	33.3%	0.0%
Totals (N=24)	54.2%	45.8%	0.0%

In contrast to the results of the questions on interest in Science and Math, more teachers felt that PIMS increased students' understanding of Math than of Science. However, in both cases, approximately half of the teachers indicated that PIMS had increased student understanding of the subject.

Figure VII summarizes teachers' observations on the effect of PIMS on students' performance in Science and Math.

Figure VII

Effect of PIMS on Students' Performance

Area of Emphasis	Teacher Ratings		
Performance in Science	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	62.5%	37.5%	0.0%
Students of Math Teachers (N=11)	18.2%	81.8%	0.0%
Students of Teachers of Both Science and Math (N=3)	33.3%	66.7%	0.0%
Totals (N=22)	36.4%	63.6%	0.0%
Performance in Math	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	50.0%	50.0%	0.0%
Students of Math Teachers (N=13)	30.8%	69.2%	0.0%
Students of Teachers of Both Science and Math (N=3)	33.3%	66.7%	0.0%
Totals (N=24)	54.2%	45.8%	0.0%

Fewer than half of the teachers responding felt that PIMS had increased students' performance in either Science or Math. However, none of the teachers felt that performance had decreased as a result of the integration of Science and Math.

Figure VIII summarizes teachers' observations on the effect of PIMS on students interest in and understanding of the relationship between Science and Math.

Figure VIII

Effect of PIMS on Students' Interest in and Understanding of the Relationship Between Science and Math

Area of Emphasis	Teacher Ratings		
Interest in the Relationship Between Science and Math	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	87.5%	12.5%	0.0%
Students of Math Teachers (N=12)	75.0%	25.0%	0.0%
Students of Teachers of Both Science and Math (N=3)	66.7%	33.3%	0.0%
Totals (N=23)	78.3%	21.7%	0.0%
Understanding of the Relationship Between Science and Math	**Increased**	**Remained Same**	**Decreased**
Students of Science Teachers (N=8)	87.5%	12.5%	0.0%
Students of Math Teachers (N=13)	84.6%	15.4%	0.0%
Students of Teachers of Both Science and Math (N=3)	66.7%	33.3%	0.0%
Totals (N=24)	83.3%	16.7%	0.0%

The overwhelming majority of teachers who responded felt that PIMS had increased students' interest and understanding of the relationship between Science and Math.

COMMENTS OF TEACHERS ON THEIR PARTICIPATION IN PIMS

In addition to the above survey questions, the evaluation of PIMS also allowed teachers to respond to fourteen open-ended questions regarding their participation in PIMS. These questions attempted to determine what teachers had done differently as a result of their participation; the effect PIMS had on them as teachers, their interaction with other teachers, the quality of their instruction, and the behavior of students; what teachers have learned from their participation which they will continue to use; which of the materials provided to them in PIMS were most useful; which of the materials developed during the course of the year were most useful; what they perceived as the strengths of PIMS; and what they felt would or should be the future of projects which integrate the instruction of Math and Science. The responses to these questions are analyzed in the following section of this report.

What have you done differently this year in your classroom as a result of your participation in PIMS?

Eight teachers responded that they stressed the inter-relationship of Math and Science in their instruction, and attempted to demonstrate the relevance of one to the other. Seven teachers indicated that they planned activities which demonstrated to relationship of Math to Science, while another seven said that they integrated their lessons with the use of examples and problems. Three teachers cited participation in Math/Science contests, while two mentioned working and planning with other teachers.

What effect has this project had on you as a teacher?

Twelve teachers indicated that it made them more aware of the relationship between Math and Science. Eight said that it either increased their enjoyment of teaching or renewed their enthusiasm and interest. Three mentioned that it caused them some inconvenience by having to plan with other teachers and conceive of examples of the interaction of Science and Math, while two reported that it had no effect on them as teachers.

What effect has this project had on your interactions with other teachers?

Twenty teachers reported positive effects on their interaction with teachers, citing such things as improved communication and the sharing of teaching ideas. Two teachers said that there had been no change, and two teachers reported that it had caused conflicts among participating teachers who had difficulty agreeing on how to integrate their instruction.

What effect has this project had on the quality of your instruction?

Thirteen teachers felt that participation in PIMS had increased or enhanced the quality of their instruction, while three more indicated that it had made them more creative. Another three said that the quality of their instruction was good before their involvement with PIMS, and that it was still good. Finally, four teachers reported that there had been no change in the quality of their instruction as a result of their participation in PIMS.

What effect has this project had on the behavior of your students?

In response to this question fourteen teachers answered that they had not observed any behavior changes in their students as a result of having the instruction of Math

and Science integrated. Three teachers felt that students demonstrated more interest and involvement in the subject matter, while two reported simply that student behavior was "better." One teacher reported that students enjoyed the change away from paper and pencil activities, another reported that students initially resisted the teaching of Math in Science class but no longer did, and another teacher observed that the integration of the two subjects caused confusion among students.

What have you learned from your participation in this project that you will continue to use as a teacher?

It was felt by twelve teachers that they were more aware of opportunities to integrate the teaching of the two subjects, and that they were also more aware of the value of presenting Science and Math instruction in a coordinated fashion. Eight teachers responded that they would continue to share and develop ideas with other teachers, while another teacher would continue to provide hands-on demonstrations of the interrelationship of Math and Science as needed for instruction. Another teacher reported that an emphasis on higher level thinking and the presentation of perceptual problems would continue following involvement in PIMS.

Which of the materials provided or developed in the Summer Institute have been most useful?

Some teachers identified specific materials or resources in response to this question, while others referred to topics or general collections of materials. Six teachers identified Comet as having been most useful, while another six mentioned the ideas obtained from other teachers. Two teachers cited Interactions with Mathematics and Science, two referred to Making Every Minute Count, and two felt that the materials from the summer workshop had been most useful. One teacher each mentioned the Notebook of Ideas and the general information made available through the program. Three teachers reported that none of the materials had been helpful.

Which of the materials developed by participants in the course of the project have been most useful?

Since the responses to this question were so varied, each response is listed separately below.

- Ideas for contact and where to find materials that could be useful.
- Cooperate with Science teacher, who has equipment such as microscopes, metric measurement, and scales.
- Mini Science lessons from Taylor.
- Lab activities.
- Hand-outs have generated ideas on lessons.
- Those related to Earth and Physical Science, since I teach those subjects.
- I've used many of the ideas. Just a chance to hear (in small groups) what people are doing has been helpful.
- "Ideas" shared by others helped most. Just brainstorming.
- Monthly presentations by various teachers have fostered ideas throughout the year.
- None. All the materials were developed for 7th and 8th. They were too hard for 6th grade, and they aren't related to Life Science.
- Metric system activities.
- A variety of materials and activities to determine volume, mass, and length.

- None of it has been useful to me. Very little has dealt with Life Science. I still feel like I'm out here alone reinventing the wheel.
- Materials developed at our school, particularly use of Math, Science, and Computer data base experience.
- Hands-on ideas.
- Lesson plans.
- The integrated plans on specific activities which were done by each teacher - These ideas were all very good for the classroom.
- Our integration chart has been the most useful piece of information. At a glance we can see in what direction we should approach our integration.
- Contests (egg drop, tower building, etc.) and speakers brought to school to inform students how Math and Science interrelate. These have provided an extra spark of interest in my class.

Which of the materials provided or developed in PIMS have been least useful?

Again, since the responses to this question were so varied, each response is listed separately below.

- I found most ideas useful or thought provoking.
- PIMS integration outlines.
- The ones that had little to do with what I was teaching. While many of the projects or materials were interesting I couldn't use them in earth Science.
- Those not related to my subject area.
- Content outlines.
- Interactions in Math and Science. Their activities are too complex for the middle school.
- 1. Content outlines.
  2. The Math-Science ideas from the summer were above the level of our students.
- Pages of philosophy and educational gobble-dee gook.
- Comet.

What do you view as the strengths of PIMS?

Nineteen teachers indicated that the sharing of ideas and cooperation with other participating teachers had been the strongest point of the program. Four felt that the strongest point had been that it was an attempt to interest students and motivate them to consider Math and Science studies in an integrated fashion.

Will your efforts to integrate Math and Science in the classroom continue?

In response to this question, twenty-three teachers responded "yes," and one responded "on a personal basis, as time and effort dictate."

Do you think PIMS should be repeated with another group of teachers?

Of twenty-two teachers who responded to this question, nineteen answered "yes," two answered "maybe," and one answered "no."

How would you improve PIMS if it should be repeated?

Once again, this question produced a diversity of comments. They are delineated below.

- I would have the group decide their own purpose and goals and allow them to implement the program, rather than being told how to proceed.
- Devote more time to planning of lessons and continue sharing of ideas. I would have liked to see others' video tapes. Provide incentives ($300) to teachers for developing lessons in writing and video taping new lessons.
- More time should be spent on actual projects and approaches.
- Keep the format used initially - the active sharing and working together on ideas and lessons developed for class work.
- Let individuals do what will be most helpful to them.
- Allow more "team" work on a regular basis so as to allow for integration through specific communication and specific concepts and topics.
- A morale-boosting component is important. Teachers trying new things need courage to continue. I work with kids who take a long time to grasp something and I have fought a constant battle with wondering how my students could possibly learn - or better yet, how I could possibly teach - some of the sophisticated things presented at our monthly meetings.
- More activities worked out. More areas for Life Science explored.
- Less paper work - more thinking; hands-on and originality.
- Emphasize curriculum planning and development.
- Past experience would be helpful for me.
- I feel that there should be more opportunities for teachers at each school to develop their topics and modes of integration unique to their particular school.
- Develop possible Science/Math topics for each unit taught in the curriculum; spend less time on individual teacher's lesson plans.
- I would have teachers from the same grade levels get together to plan activities and integration more often.

In summarizing the responses to open-ended questions, it appears that the majority of teachers participating in PIMS changed both the way they planned lessons and the way they presented material in class as a result of the program. Teachers reported that they stressed the relationships between Math and Science, presented examples and problems to illustrate those relationships, and included more activities in their lessons. It was reported that the program helped them raise their awareness of the relationship between Science and Math, and that it improved the communication among teachers of the same subjects and between teachers of different subjects. They felt that it enhanced and improved the quality of their instruction, for the most part, but that it did not have an effect on the behavior of their students. Nearly all participating teachers indicated that they would continue to integrate the instruction of Math and Science next year, and would attempt to coordinate lesson plans with their Math or Science counterparts. Almost all of the participating teachers also felt that PIMS should be repeated again next year with a different group of teachers.

CONCLUSION

During the 1986-37 school year, twenty-four Science and Math teachers from six APS middle schools participated in the Program to Integrate Math and Science, which was funded by a grant from the TRW Foundation. Under this program, teachers attended a two week summer institute, which was continued through the school year with monthly meetings of all participating teachers. In addition, Science and Math teachers at each participating school met regularly to coordinate the instruction of their respective subjects.

At the final monthly meeting, surveys were given to all twenty-four participating teachers. Of those, nearly all felt that using the objectives of the program had enhanced the quality of their instruction. Slightly more than half felt that the program had increased students' understanding of Math, while exactly half felt that it had increased students' interest in Math. Just over half reported an increase in students' interest in Science, while slightly fewer than half felt that the program had increased students' understanding of Science.

The majority of teachers surveyed indicated that the program had no effect on students' performance in Science or Math. However, most felt that it had increased both students' understanding of and interest in the relationship between Science and Math.

The majority of teachers participating in PIMS reported that they changed both the way they planned lessons and the way they presented material in class as a result of the program. Teachers felt that their awareness of the relationship between Science and Math had increased, and communication and sharing among teachers had improved as a result of participation in the program. Nearly all participating teachers reported that they would continue to plan with other teachers to integrate the instruction of Science and Math, and felt that the program should be repeated again with a different group of teachers.